SYNTHESIS: UPLAND AND LOWLAND VIEWPOINTS
The studies from the chapters 2 to 6 provide the first paleoecological publications on Mauritius. These climate reconstructions were compared to lake records from the African continent (Chapters 2 and 3), Indian Ocean marine records, and monsoon stalagmite records from Asia and Australia (Chapters 5 and 6); the Mauritian vegetation dynamics are paralleled with paleoecological records from other (oceanic) islands, and compared to ecosystem dynamics characteristic of continents (Chapters 2, 3 and 4).

A stark contrast is evident between upland and lowland sites in terms of the age range of the sediment archive, preservation of fossils, and the dynamics from externally driving mechanisms. Therefore, in the synthesis, we address the natural history of Mauritius from the different upland and lowland viewpoints.
7.1 MAURITIUS DURING THE LAST ICE AGE (CHAPTER 2)

The 36,500 year long Kanaka Crater pollen record shows a continuous presence of montane forest, suggesting that precipitation levels during the last glacial were comparable to the present-day (Van der Plas et al., 2012). Although many paleorecords across the length of Africa show orbitally-driven monsoon changes (e.g. Partridge et al., 1997; Verschuren et al., 2009; Rampelbergh et al., 2013), the Mauritian uplands record little influence of this 23-ky periodicity. Instead, long-term high precipitation levels are facilitated by the orographic setting of the crater (Vaughan and Wiehe, 1937), warm water masses in the Indian Ocean (Prell et al., 1980; Barrows and Juggins, 2005), and the Indian Ocean Dipole (Saji et al., 1999; Marchant et al., 2006).

Long-term stable composition of montane forest in the Eastern Arc Mountains in Tanzania and Kenya were facilitated by the low amplitude of temperature and precipitation change across glacial to interglacial time periods (Mumbi et al., 2008; Finch et al., 2009). The Kanaka Crater record, however, shows a clear contrast between the glacial and Holocene forest composition: the glacial forest (36,500 – 11,500 cal yr BP) is an open, wet, unstratified montane forest dominated by trees of *Nuxia verticillata*, *Weinmannia*, *Syzygium*, *Tambourissa*, *Cycadaceae* and *Securinega durissima*, and *Cyathea* tree ferns; the Holocene forest (7600 – 2300 cal yr BP) is a closed, relatively drier, stratified montane forest dominated by sapotaceous canopy trees, understorey trees *Securinega durissima*, *Allophyllus* and *Molinaea*, interspersed with *Dracaena* palm-like growth forms and emergent *Latania* palms. The first publication of the Kanaka Crater pollen record (Van der Plas et al., 2012) suggests that a re-assortment in taxonomic composition of montane forests might act as an alternative response mechanism to glacial-interglacial climate change; opposed to a displacement of forest types to new altitudinal intervals as recorded on the continent.

The glacial and Holocene forests described from the Kanaka Crater pollen record reflect long-term steady states in forest composition. When, how and why did montane forest cross a threshold between these two steady states?

7.2 STEADY STATES AND RAPID SUCCESSION (CHAPTER 3)

A high-resolution vegetation reconstruction (up to 20-yr between samples) reveals a rapid succession of different plant associations starting at the onset of the Holocene (De Boer et al., 2013a). An apparent critical threshold was crossed at 11,500 cal yr BP, after which the montane forest system was propelled into an unstable period lasting for 4000 years. This regime shift from a stable glacial to a stable Holocene forest associations is expressed by four abrupt species turnover events. The first step of the cascade is situated at the Lateglacial – Holocene transition 11,500 years ago: *Nuxia verticillata* and *Weinmannia* lose ground over *Cycadaceae*, *Tambourissa*, *Syzygium*, *Psiloxylon mauritianum* and Arecaceae type 137. The largest species turnover event
takes place at 9600 cal yr BP, when Cycadaceae, Tambourissa and Syzygium are replaced by Nuxia verticillata, Weinmannia, Eugenia, Allophyllus, Securinega durissima, Euphorbiaceae type 112 and Dracaena/Latania. In the subsequent turnover events at 8500 and 7600 cal yr BP, Nuxia verticillata, Weinmannia, Psiloxylon mauritianum, Areaceae type 137 and Eugenia are replaced by Sapotaceae and Dodonaea. Based on growth rates and stem widths, the lifetime of one generation of a canopy tree can reach up to three centuries and for some species even exceed 1000 years (Baider and Florens, 2006; Florens, 2008); each species turnover event occurred in less than 150 years and therefore demonstrate an astonishingly rapid replacement of plant associations within two tree generations.

The initial change occurred at the Late Glacial to Holocene transition at 11,500 cal yr BP suggesting that a shift to Holocene global climatic conditions, such as high atmospheric levels of greenhouse gasses or the evolution of the meridional overturning circulation, pushed the Mauritian montane forest biome into instability. The subsequent events of species turnover do not coincide with climate events of global, African, or SW Indian Ocean significance. Therefore, the cascade of discrete plant associations could be driven by intrinsic forest dynamics (Williams et al., 2011).

A clear case of internal forest dynamics is illustrated by the centennial increase of Nuxia verticillata after 4900 cal yr BP (Chapter 3, Fig. 5). Nuxia is a light-demanding canopy tree in wet environments and requires ‘stems’ of Cyathea tree ferns or dead wood for germination (Rivière et al., 2008; Baider and Florens, 2012, pers. comm.). Few light would penetrate the canopy of the well-stratified Sapotaceae-dominated forest that grew at Kanaka Crater around that time. Only a substantial mortality of Sapotaceae trees, perhaps from a landslide of the steep unstable crater walls, would have created an opportunity for Nuxia to expand. It is less likely that Sapotaceae trees were thrown down during a storm event, as Sapotaceae canopy trees are well adapted to cyclones that hit Mauritius several times per century (Vaughan and Wiehe, 1941), and no extreme climatic event was recorded in other Mauritian records.

Increasing the number of ‘subject cases’, against which the robustness of the dynamics at Kanaka Crater can be assessed, is essential to get a better understanding of the potential drivers of forest dynamics at the onset of the Holocene. Palynological analysis of the Grand Basin Crater is currently underway to test if any similar vegetation dynamics can be recorded at a site at 3 km distance and comparable in altitude and environment to the Kanaka Crater. If montane forest dynamics at Grand Basin Crater are similar in timing, species composition, and/or direction of change of plant associations (e.g. a movement towards a drier forest type) as those observed at Kanaka Crater, we assume there is a common external driver in the Mauritian uplands (i.e. climate change); if the dynamics at Grand Basin Crater have a different chronology, different species composition, and/or a different direction of plant associations, we assume an important role of intrinsic forest dynamics (e.g. interspecific competition) (E.J. de Boer & A.P. Sandoval, 2014, unpublished data).
7.3 THE PARADOX OF ISLAND STABILITY UNVEILED

How do the documented dynamics of the Mauritian uplands fit with the paradigm of island stability presented in the introduction? Indeed, we find no evidence of abrupt climate change in the uplands but instead record stable environmental conditions. As described in the previous sections, the montane forest biome appears stable for long periods of time, but also documents shorter periods of rapid species turnover. Perhaps, despite relatively low diversity and low immigration rates (Cronq et al., 1997; Chapter 1), interspecific competition plays a more important role in the upland forests than anticipated.

Although the overall diversity on islands is lower compared to continents, plant niches potentially have a large overlap as ecological zones are more compressed on insular settings (e.g. the Massenerhebung effect). Vaughan and Wiehe (1941) described that the second stratum of montane forest, which forms an interlocked canopy at 11 – 15 m height, accounts for a great density of forty species distributed among eighteen families. The top stratum reflects large emerging canopy trees (15 – 20 m height) comprising of twelve species of which seven belong to the Sapotaceae family (Vaughan and Wiehe, 1941). Two of the five wet forest palm trees, Acanthophoenix rubra and Dictyosperma album, would also have penetrated the second stratum and form a ‘double canopy’ forest (De Saint Pierre, 1773; Cheke and Hume, 2008; Thébaud, 2009; Florens et al., 2013). The large number of unknown Arecaceae pollen types (see next section) suggests that more palm species were part of this double canopy forest. The large number of plants that potentially constitute the different forest strata fits with the ephemeral nature of plant associations described in the upland pollen records: if there is a strong competition in these forest, plants would wait for a window of opportunity to rapidly replace its competitor. Currently, the beta-diversity of wet forest is still relatively high in the Mauritian uplands (Florens et al., 2013). For some species, juveniles can stay ‘dormant’ in the understorey for several decades waiting for the moment to rapidly grow towards the canopy (Florens and Baider, 2012, pers. comm.). As climate conditions in the uplands are relatively similar, the different species compositions between vegetation plots would be determined by stochastic processes.

While the low altitudinal range of Mauritius may cause a large overlap in the upland vegetation distribution (Chapter 3, Fig. 2), would similar dynamics occur on islands where vegetation is altitudinally constrained? The neighbouring island Réunion is volcanically active and reaches over 3000 m in elevation. The vegetation is clearly separated in different vegetation bands determined by precipitation and altitude (Strasberg et al., 2006). To date, no paleoecological studies have been performed on Réunion, and it would be highly interesting to document past vegetation changes in terms of shifting ecotones, ephemeral associations, or both. A future challenge is to study if the observed past dynamics in the Mauritian uplands reflects a typical insular response to climate change (i.e. in areas where migration is hampered, you get a re-assortment of taxa), or that each island responds differently according to their topology, age and climate.
The replacement of taxa in the Mauritian uplands contrasts with continental dynamics, as African continental pollen diagrams show a gradual accumulation of biodiversity over time (e.g. Hooghiemstra et al., in press). Perhaps we can compare the rapid succession of plant associations in the Kanaka Crater with the invasion of ‘alien’ species. Currently, the largest threat to the Mauritian diversity is invasion of exotic species (Lorence and Sussman, 1986; Caujapé-Castells et al., 2010). Did these past events of replacement also cause extinctions?

7.4 THE LOST VEGETATION OF MAURITIUS

No evidence was found in the pollen records of natural plant extinction/extirpation. We assume that taxa being replaced by others would be able to reside elsewhere, using gallery forests as biodiversity reservoir and migration corridor (Mayle et al., 2007; Chapter 3). In the Kanaka Crater for example, glacial forest taxa Nuxia, Weinmannia, Syzygium and Eugenia increase after 2300 cal yr BP, being (almost) absent for several thousands of years. Other taxa, such as Erica and Cycadaceae, disappear from the Kanaka Crater, but remain present in other records such as Pétrin and Grand Basic Crater until the recent past.

The suite of fossil pollen taxa of which the parent plants are currently – in the absence of paleoecological studies - not considered native to the Mauritian flora most likely went extinct rapidly after colonization in AD 1638. Already large areas of forest were destroyed before the first reliable botanical surveys took place in the 1800s (Cheke and Hume, 2008). The fact that new species are still being discovered (e.g. Florens and Biader, 2006; Le Péchon et al., 2011; Baider et al., 2012, 2013; Baider and Florens, 2013) shows there are significant gaps in the current knowledge of the native status and distribution of the Mauritian flora.

The first floral descriptions of Mauritius by the Dutch focused mainly on those plants that were easy to recognize and provided sources for primary life support (Cheke and Hume, 2008; Prebble and Dowe, 2008). Ebony (Diospyros spp.) was an extremely valuable timber, while palm trees supplied leaves to build roofs for houses, palm heart (also called ‘cabbage’ or ‘chou’) supplied an important source of fresh food, and water tapped from certain palm species was fermented in barrels for several days and turned into ‘palm wine’ (De Saint-Pierre, 1773; Maunder et al., 2002; Cheke and Hume, 2008). These valuable plants were harvested in great amounts and disappeared rapidly from the landscape. The ‘double canopy’ forest described by early sailors (Chapter 6, Fig. 9) is non-existent nowadays. Current descriptions of vegetation plots in the last pockets of native upland Table 1. All palm (and Cycadaceae) pollen types found in Mauritius (ab = abundant, co = common, ra = rare; Pétrin = Le Pétrin, Kanaka = Kanaka Crater, GB = Grand Basin Crater, Tatos = Mare Tatos, MAS = Mare aux Songes). 1Based on Maunder et al. (2002). forest are completely devoid of palms (Florens et al., 2012). Palms would have been harvested even in the most remote areas of Mauritius, as escaped slaves (‘marrons’) would depend on them for their survival.
Table 1. All palm (and Cycadaceae) pollen types found in Mauritius (ab = abundant, co = common, ra = rare; Pétrin = Le Pétrin, Kanaka = Kanaka Crater, GB = Grand Basin Crater, Tatos = Mare Tatos, MAS = Mare aux Songes). Based on Maunder et al. (2002).

<table>
<thead>
<tr>
<th>Pollen taxon</th>
<th>Plant taxon</th>
<th>Local name</th>
<th>Pétrin</th>
<th>Kanaka</th>
<th>GB</th>
<th>Tatos</th>
<th>MAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthophoenix T.mau-54b</td>
<td>Acanthophoenix rubra</td>
<td>palmiste</td>
<td>X (ra)</td>
<td>X (co)</td>
<td>X (co)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthophoenix T.mau-323</td>
<td>Acanthophoenix rubra</td>
<td>palmiste</td>
<td>X (co)</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dictyosperma types</td>
<td>Dictyosperma album var. album</td>
<td>princess palm</td>
<td>X (ra)</td>
<td>X (ab)</td>
<td>X (ab)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyophorbe type</td>
<td>Hyophorbe amaricaulis</td>
<td>lonely palm</td>
<td>X (ra)</td>
<td>X (ra)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyophorbe type</td>
<td>Hyophorbe lagenicaulis</td>
<td>palmiste gargoulette</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyophorbe type</td>
<td>Hyophorbe vaughanii</td>
<td>Vaughan’s bottle palm</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latania types</td>
<td>Latania loddigesii</td>
<td>latania</td>
<td>X (ab)</td>
<td>X (ab)</td>
<td>X (ab)</td>
<td>X (ab)</td>
<td>X (ab)</td>
</tr>
<tr>
<td>Tectiphiala ferox T.mau-170</td>
<td>Tectiphiala ferox</td>
<td>palmiste bouclé</td>
<td>X (ra)</td>
<td>X (ra)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oncosperma type</td>
<td>Oncosperma fasciculatum</td>
<td>katu kitul</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deckenia T.mau-54c</td>
<td>Deckenia nobilis</td>
<td>millionair’s salad</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deckenia T.mau-54c</td>
<td>Deckenia nobilis</td>
<td>millionair’s salad</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycadaceae type</td>
<td>Cycadaceae</td>
<td>sago palm</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>T.mau-2</td>
<td>?</td>
<td>?</td>
<td>X (ra)</td>
<td>X (ab)</td>
<td>X (ra)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T.mau-127</td>
<td>?</td>
<td>?</td>
<td>X (co)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T.mau-137</td>
<td>?</td>
<td>?</td>
<td>X (co)</td>
<td></td>
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</tbody>
</table>
Instead of five native genera (Maunder et al., 2002), the pollen record indicates that more than ten palm types were native to Mauritius (Table 1). These palm types reflect a wide range of pollen morphological characters and may therefore reflect separate genera. Some morphological characters were unique for monocotyledons (e.g. the decussate tetrade T.mau-2) (M. M. Harley, 2012, pers. comm.) and may present extinct palm genera. The full extent of the lost vegetation of Mauritius hasn’t been uncovered yet, as new palynological data continues to reveal novel (monocotyledon) pollen types (E.J. de Boer & A.P. Sandoval, 2014, unpublished data).

7.5 NATURAL BASELINE OF THE AZONAL UPLANDS (CHAPTER 4)

To get a better understanding of the human impact on the upland environment, we compared the natural settings before and after human arrival in the flat uplands around Le Pétrin (De Boer et al., 2013b). Granulometric analysis of the record shows that the shallow sediments in these flat uplands are mainly derived from weathering of basaltic rocks, and are accumulated over long periods of time. However, small pools of stagnant water provide local reservoirs where organic material can be accumulated. The 1000-yr long pollen record from Pétrin showed a mosaic display of marsh, ericaceous heathland and stunted forest, with changes driven by local hydrological and edaphic characters that over millennial timescales. Pandanus- and fern-dominated marshes grew in waterlogged areas, and ericaceous heathland grew on better drained surfaces, while wet forest taxa grew inside the heathlands as stunted forest and on the surrounding slopes. Although ericaceous heathland and wetland forest share many species, this study disagrees with the conclusion of Vaughan and Wiehe (1941) that ericaceous heath represents the initial stage in the development of ‘climax’ forest (montane forest). 

Erica heath is currently restricted to an area less than 0.5 km², but occurred much larger areas before colonization (Chapters 2, 3 and 4; De Boer & Sandoval et al., in preparation); these areas are now occupied by pine plantations and secondary stunted forest (De Boer, 2010-2014, pers. obs.). Ericaceous heath is adapted to xeric conditions from bare lava slabs and immature and highly laterized soils (Vaughan and Wiehe, 1937). While individual montane forest taxa can be found inside the heathlands as stunted trees, an fully developed ‘climax’ forest would only develop on more sloped parts of the uplands.

The destruction of natural landscape after colonization is documented by a sudden appearance of exotic species, deforestation, fire evidenced by charcoal particles, and increasing abundance of grassy vegetation reflecting degraded vegetation. The invasive strawberry guave (Psidium cattleianum) forms dense thickets and is a major threat to all upland forest areas. Pine (Pinus) and tea (Camellia sinensis) were introduced in the 19th century (Kueffer and Mauremootoo, 2004).
While small patches of montane forest have persisted in the uplands of Mauritius, the lowland forest have been as good as completely destroyed by man. Descriptions of lowland vegetation zones from historical records indicate the occurrence of semi-dry forest (0 – 360 m elevation; 1000 – 1500 mm annual rainfall) and palm woodland (0 – 200 m elevation; < 1000 mm annual rainfall) (Cheke and Hume, 2008). The lowlands are much more sensitive to changes in precipitation because the mean annual evapotranspiration is similar or higher than the mean annual precipitation, in particular during the dry season in the austral winter (Senapathi et al., 2010).

This sensitivity was used to reconstruct in detail the Holocene climate of Mauritius from the Tatos wetland in the northeastern coastal lowlands. Hydrological analyses showed that these coastal wetlands receive a surplus of water from surrounding higher grounds. During drier periods, decreased inflow of fresh groundwater and increasing evapotranspiration rates raises the fresh-salt groundwater interface. Therefore, changing precipitation can be deduced from changes in salinity. Salinity and environmental reconstructions based on diatoms, ostracods, stable isotopes, and sediment compositions were performed to disentangle and assess the different
influences over time of rising sea levels and precipitation change. In addition, the abundance of semi-dry forest and palm woodland reconstructed from the pollen record provides an independent proxy of regional climate (Fig. 1; De Boer et al., 2014).

The reconstructed millennial-scale precipitation changes (8000 – 6800 cal yr BP, wet; 6800 – 1200 cal yr BP, dry; 1200 cal yr BP – present, wet) reflect northern hemisphere monsoon activity. Although Mauritius receives most precipitation during the northeast monsoon (opposite to the Indian Summer Monsoon), the northern hemisphere monsoon is more prominent in the record than the southern hemisphere monsoons. This northern hemisphere monsoon signal may have overwritten the southern hemisphere monsoon, as the Asian landmass experiences larger climate variability than the Indian Ocean water surface on the southern hemisphere.

Secondly, modern observations show that the southern equatorial Indian Ocean is the dominant source of moisture for the Asian boreal summer monsoons, indicating that Mauritius shares a common moisture source with Indian Summer Monsoon (ISM) and Asian Summer Monsoon (ASM) rainfall (Rohling et al., 2009; Clemens et al., 2010).
During the middle Holocene, a distinct contrast between western and eastern Indian Ocean climate is present, as Mauritian climate became drier while the Austral-Indonesian summer monsoon was enhanced (Partin et al., 2007; Griffiths et al., 2010; Denniston et al., 2013). The relative dry conditions in Mauritius correspond with decreasing strength of ISM (Gupta et al., 2005; Fleitmann et al., 2007) and decreasing ASM rainfall (Wang et al., 2005), and distinct lower temperatures in the Kilimanjaro record. We proposed that these middle Holocene rainfall patterns demonstrate a prolonged negative Indian Ocean Dipole (IOD)-like configuration of the Indian Ocean.

Superimposed on the generally dry climate conditions during the middle Holocene, the Tatos record identified multiple decadal to centennial wet events. These abrupt events correspond with short amplitudes of decreased strength of the Australian Indonesian Summer Monsoon (AISM; Denniston et al., 2013), thereby reflecting positive IOD-like events during which a northward shift of the Intertropical Convergence Zone (ITCZ) enhanced upwelling in the eastern Indian Ocean and strengthened ASM rainfall (Abram et al., 2007; 2009).

Climate conditions in the Mauritian lowlands were relatively stable between 4000 and 2650 cal yr BP, while humidity remained relatively low. Reduced precipitation in both the eastern and western equatorial Indian Ocean has been associated with weakening of AISM rainfall after 4200 cal yr BP (Partin et al., 2007; Griffiths et al., 2010; Denniston et al., 2013). Increased climate variations linked to El Niño Southern Oscillation (ENSO)-variability have been revealed in the Caribbean Sea (Donnelly and Woodruff, 2007), Peru (Moy et al., 2002), the Eastern Pacific (Toth et al., 2012), the Galápagos islands (Conroy et al., 2008), the Indonesian shelf (Gagan et al., 2004) and Australia (Donders et al., 2008). These studies show that ENSO frequency and intensity increased between 5000 and 4000 cal yr BP and became the dominant forcing of late Holocene climate variability in tropical and subtropical regions (Moy et al., 2002; Gagan et al., 2004; Donders et al., 2007, 2008; Conroy et al., 2008; Toth et al., 2012).

Increased input of biogenic CaCO₃ in the Tatos basin after 2650 cal yr BP reveals an increase in droughts and storm activity. Mauritian storm events correspond with weakening of the boreal summer monsoons (Wang et al., 2005; Fleitmann et al., 2007) and an abrupt reduction of upwelling in the Arabian Sea (Gupta et al., 2005). The droughts and increased storm activity after 2650 cal yr BP are also linked with El Niño – Southern Oscillation (ENSO) events in lake Pallcacocha in Peru (Moy et al., 2002) and extreme ENSO events in the eastern Pacific (Conroy et al., 2008; Toth et al., 2012), as well as lowest AISM rainfall between 1500 and 1200 cal yr BP in western tropical Australia (Denniston et al., 2013). Conroy et al. (2008) relate the shift at 2600 cal yr BP to the decoupling of ENSO from the Atlantic ITCZ. Without the southward migrations of the Atlantic ITCZ into South America during which climate variability was enhanced in the Cariaco Basin between 4000 and 2600 cal yr BP (Haug et al., 2001), ENSO events developed that also affected climate events in the SW Indian Ocean.
The onset of increased ENSO-activity after 4000 cal yr BP was preceded by the driest conditions in the Mauritian lowlands recorded around 4300 cal yr BP. These driest conditions correspond to a global-scale period of monsoon weakening, which is considered as the driver of civilization collapses in Pakistan, Mesopotamia and eastern Africa (Cullen et al., 2000; Thompson et al., 2002; Staubwasser et al., 2003; Wang et al., 2005; MacDonald, 2011). This ‘megadrought’ coincides with wettest conditions in tropical western Australia (Denniston et al., 2013), and may therefore represent an anomalously strong negative IOD event.

### 7.7 FRESHWATER IN THE COASTAL LOWLANDS

Standing freshwater in the lowlands is rare due to rocky basaltic soils with poor water retention capacity and high evapotranspiration rates (Rijsdijk et al., 2009). Shallow lakes in the dry coastal lowlands, such as Tatos and Mare aux Songes, resembled oases for the Mauritian fauna. Abundant coprophilous fungi, growing on dung of larger vertebrates, indicate that animals were attracted to these wetlands in large concentrations.

In 2005, a rich fossil bed was discovered at Mare aux Songes (MAS), a wetland in the southeast coastal lowlands (Rijsdijk et al., 2009). The fossil depository constitutes a Lagerstätten with more than 250 bone fragments/m² from a diverse spectrum of plants and animals, including the dodo (*Raphus cucullatus*) and giant tortoises (*Cylindraspis* spp.). Radiocarbon dating of vertebrate bones, wood and seeds indicate that fossils accumulated between 4235 and 4100 cal yr BP, suggesting that more than half a million vertebrate individuals died within a time frame of less than 150 years (Rijsdijk et al., 2011).

This setting provided an unprecedented opportunity to examine in detail the impact of a natural catastrophe on a rich insular ecosystem. What were the environmental conditions that preceded and prevailed during the mass mortality events, and what factors induced mass mortality? Why is the evidence for this vertebrate mass mortality exclusively documented at MAS on Mauritius and not elsewhere on other islands?

### 7.8 DEADLY COCKTAIL (CHAPTER 6)

Analysis of pollen, diatoms, pigments and hydrological measurements provide a unique window in how a very rich fossil bone bed developed at MAS 4200 years ago (Fig. 2; De Boer et al., in prep.). A reconstruction of regional vegetation change and local wetland development under influence of sea-level rise and inferred climate change between 4400 and 4100 cal yr BP was compared to the climate reconstruction at Tatos (Chapter 5). A prolonged drought in Mauritius and around the Indian Ocean is recorded between 4330 and 4130 cal yr BP. This abrupt increased aridity induced fires on Mauritius and at MAS, and caused in the MAS-site lowerwater-levels. The
Fig 2. Selection of mural of pristine Mare aux Songes: Mauritius palm-rich Dodo habitat ca. 4000 years ago, based on pollen and fossil wood analysis (painting by Julian P. Hume; artwork commissioned by Tamara Vernimmen and Erik J de Boer).

lake shrank resulting in a further concentration of animals in the wetland. Upconing of the saline wedge underlying the fresh water hole induced progressive salinization. The excrements of the animals, indicated by the presence of coprophilous fungi and N-tolerant diatoms, led to hypertrophic conditions. These polluted conditions combined with salinization and high temperatures were suitable for cyanobacteria blooms of which traces of pigments have been found. Ultimately these factors led to a deadly cocktail of salinification, eutrophication and regional fire, which resulted in the death of 100,000s of vertebrates by intoxication, dehydration, trampling and miring.

Even though at MAS preferential taphonomic conditions led to a unique conservation of fossils, the 4200 cal yr BP aridity event must have induced similar bottlenecks elsewhere around the Indian Ocean. The ‘4.2 ka megadrought’ was a phenomenon of global impact (Davis and Thompson, 2006) and is considered as the driver of civilization collapses in Pakistan, Mesopotamia and eastern Africa (Cullen et al., 2000; Thompson et al., 2002; Staubwasser et al., 2003; Wang et al., 2005; MacDonald, 2011). It is hypothesized this megadrought reflects an anomalously strong IOD event (Chapter 5). Therefore, the uniqueness of the MAS fossil layer lies in the fact that it reflects the direct consequence of a natural catastrophe in an insular ecosystem, and challenges the stability paradigm of climatologically inert islands.

7.9 ANOTHER DAY IN PARADISE?

Nowadays, Mauritius is visited by 100,000s of tourist and honeymooners each year that want to experience their share of paradise. But for the dodo and its contemporaries, even with no predators around, conditions were at times harsh on this subtropical oceanic island. We should not consider them stupid to have gone extinct, but laude them for their survival through all of the Quaternary. Ultimately, the dodo and its contemporaries were unable to resist the dramatic impact of invasive species, including Man, and became extinct.

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